Selection of US EPA field sites located in Oregon

The US Environmental Protection Agency, Western Ecology Division laboratory located in Corvallis Oregon undertook the establishment, maintenance, and operation of numerous meteorological monitoring stations. The field sites where these stations were installed were selected to meet three separate modeling objects:

1. The initial sites (Toad Creek and Falls Creek) were selected to provide data for parameterizing the Woods Hole General Ecosystem biogeochemical Model (GEM).
2. The remainder of the sites in Oregon were selected to test the performance of the model across a wide range of climate and edaphic conditions. Data from these sites will be used to test and improve the original parameterization of the model. These sites range from the Pacific coast to over the east slope of the Cascade Mountains and represent a wide range of temperature, precipitation, soil properties and plant productivity.

In the selection of field sites, for developing and testing the model parameterization and model validation, a number of factors were considered.

1. Select sites that had not been impacted by forest management practices or where the impact was small.
2. Two sites (Soapgrass and Middle Santiam) were selected because they represent the maximum standing biomass for a low and a high elevation Douglas-fir forests.
3. The sites were selected to represent a range of precipitation, temperature, soil N, species composition and plant productivity. At three sites (Moose Mountain, Falls Creek and Toad Creek) there were clear cuts near the forest stands where data were also collected to provide an indication of process in sites that had been recently cut and/or replanted.

It is expected that these basic data collected from these sites will be used to provide a basic description of the stand and soil conditions at the sites that will be used in publication resulting for studies at the sites.

Approach

This document provides three basic types of information: (1) The specific location of each of the field sites and their associated meteorological towers for measuring weather and soil conditions, (2) basic characteristics of the forest stand and (3) characteristics and properties of the soils at each of the sites.

1) Field site locations

The locations of the 23 climate monitoring stations are given in Table 1. The locations of the major field sites shown in Figure 1 and show a representation of the elevation profile that extends along this transect of sites. Figure 2 shows where the sites are located along an idealized elevation profile, the physical and biological characteristics across this transect and lists the names and major features of the various sites.

Because high resolution weather and soil data are needed for the biogeochemical simulation model and other models, meteorological towers were installed at each field site. For each field site the goal was to establish two separate meteorological towers; one under the forest canopy and the other in a nearby opening or clear-cut. The site under the canopy provides information on the weather and soil conditions under the canopy and provides the best estimate of the influence of the canopy on soil moisture and soil temperature. The site in the opening or clear cut provides best estimate on the overall weather conditions for the area and provides data on the on the soil temperature and

moisture conditions in a clear-cut or open area not influenced by the forest canopy. They also serve as a proxy for the light, air temperature and precipitation at the top of the forest canopy. Between October 2008 and June 2015 a meteorological tower was installed at the top of tree adjacent to each forest site's ground meteorological tower. This was done to get a better estimate of top of canopy climatic conditions and because the meteorological equipment in the open sites were becoming obstructed from tree growth in the open area.

A new field location near Cascade Head was installed on 10/16/2015. The site, Widow Creek Forest (WCF), is located in a Douglas fir forest plantation that is approximately 25 years old. This site was installed to provide another coastal monitoring location, but one located in a very young Dougas fir stand.

Measuring weather and soil conditions

When selecting an open site or clear-cut in which to locate a meteorological tower, the goal was to select a nearby site that was similar in aspect and elevation as the forested site and was large enough so that the tower was not shaded or affected by the surrounding vegetation. In general this goal was achieved. However, it was difficult to find large enough openings near the two forested sites at Cascade Head so the decision was made to locate a single meteorological tower in the clearing adjacent to where the U.S. Forest Service has a long-term climate station. (Their station collects data on a daily time scale). At the Metolius site we established a site under the canopy and have made arrangements to obtain the necessary open data from the nearby Oregon State University Eddy Flux site. At the Juniper site we established only a single site because the trees were widely spaced and not very tall.

The locations of the meteorological towers at the Oregon field sites are given in Table 1. Also listed is the first year for which there is weather data available. However, this does not mean that every hour of data are present for these years. For most sites there are gaps in the data when there was an equipment failure or at some sites not all the instrumentation was installed at the same time.

At Falls Creek and Toad Creek the open sites were initially established to monitor the weather conditions at exclosures that were established for a study being conducted at the Western Ecology Division TERA Facility. At Falls Creek the meteorological tower was moved (~170 meters southeast) in early 2000 to its present location, in the same clear-cut, because the sensors were being shaded by trees.

The same basic weather and soil monitoring sensors were installed at each site. Figures 3 & 4 shown what typical climate monitoring stations look like for an open area and an upper canopy location, respectively. However, some sites may have some additional sensors installed based on some additional studies that were performed over time. The basic sensors that were installed at each site are listed in Table 2. Soil temperature and volumetric soil moisture are measured at several depths in the soil and those depths are listed in Table 1. Soil sensors were installed into the undisturbed face on the upslope side of a soil pit. The soil pits had the soil removed by sections and placed on a tarp so that the soil stratigraphy could be approximated when refilling the soil pit.

When the earliest climate stations were setup it was assumed that aboveground sensors were installed at the same locations on the tripod towers for all field sites. However, this was not the case, with these sensors being placed at slightly different heights above the ground, from the tower center, and at various positions around the tower center. Beginning in 1999 all existing sites, and all future sites, had their aboveground instrumentation standardized to 3-m above ground level, 75-cm from the tower center and the following true compass bearings (Air temperature/RH @ 0°, PAR @ 180°, wind speed 60°, and rain gage @ 300°). Table 3 lists the dates when sensor positions were changed from their non-standard to standard locations and the positions of the original sensors.

The names of all the data variables, the sensor manufacturer and model number used to measure a particular parameter, and the calibration frequency and procedure are found in the data file called "US EPA Climate Monitoring Data Variable Listing.csv". The file "US EPA Climate Monitoring Sensor Installation_Removal Matrix.pdf" shows the sensor installation & removal schedule by Site ID. This table shows the specific dates when sensors were installed and/or removed due to changes in sensor type used or the removal of sensors when a site was shut down.

The data records for each site are hourly averages (or totals for rainfall) of observations collected every 5-minutes. The climate stations were visited quarterly where the basic operation of all sensors were evaluated for "normal" or expected values. For some aboveground variables, they were compared with a hand-held weather station (e.g., Kestrel 4000). Missing data were data not collected due to issues such as loss of power, animal damage, human damage, or equipment failure. The data presented in the data files are raw, unadjusted data.

2) Field site – Stand characteristics

The stand characteristics for the Oregon field sites are listed in Table 4. Several types of data have been collected to characterize the vegetation on the stand. A brief description of the methods used to collect the data, with references, as appropriate are included in this section.

1. Stand age: Based on (1) the collection of trees cores and counting the number of annual rings or counting the rings in stumps in clear cuts near the stands; (2) The ages for Cascade Head were based on the ages for the stands that were determined when the sites were established in 1935.
2. Stand establishment event: The event was derived from what could be found in the history of the area where the specific site was located.
3. Dominate tree species: At the time that data were collected on the individual trees on each stand, the species of each tree was determined. The dominate tree species are those that contribute the most basal area to the stand.
4. Year of stand data: The date indicates the year that the location of individual trees in the stands were mapped. This included identifying the individual species and measuring the diameter at breast height (dbh). EPA mapped and collected data on all the stands except for Cascade Head Stand 3 where OSU provided the species identification and bole dbh data to EPA.
5. Stand Density: A count of the number of trees in the stand $\geq$20 cm dbh (except for the Juniper site where the diameter of the trunk was measured just above the soil surface) were counted and divided by the area of the plot and expressed on a hectare basis.
6. Basal Area: The diameter of each tree in the stand with a diameter of $\geq$20 cm dbh (except for the Juniper site where the diameter of the trunk was measured just above the soil surface) was converted to area assuming that the trunk was a circle. The basal area for all the trees were summed and divided by the area of the plot to express the data on a hectare basis.
7. Leaf Area Index: It was estimated for several of the plots using the light interception method (e.g., Bréda 2003). The incident radiation is measured in a large opening or clear-cut adjacent to the canopy to determine incident radiation (I_o) and at the same time radiation (I) under the canopy is measured. Leaf area index is estimated using the following equation: $LAI = -1/k * \ln(I / I_o)$ All measurements for LAI were collected within 10 days of the summer solstice and within an hour of solar noon to minimize shading from branches and tree boles

which can bias the readings. As the data were collected during the summer, the data for Falls Creek and Moose Mountain include the LAI of the vine maple understory as it was not easy to get readings above them.

8. Foliar N: Needle samples were collected from current-year needles from 6 Douglas-fir trees at three canopy locations (lower, mid and upper) in the fall of 2000. The needles were dried to a constant weight (60°C) and foliar N concentration (%) was determined in the needles by flash combustion using a Carlo-Erba EA 1108 analyzer.
9. Year of root data: The fine root data for the various stands were collected at different times and this column indicates the year that the data were collected.
10. Fine root biomass: Fine root biomass were collected in a regular pattern to a depth of 80 cm at all sites except Soapgrass (60 cm) and Juniper (100 cm).

3) Field site – Soil characteristics

To characterize the soil at each plot soil pits were dug at each site and a soil description for each site was prepared. Soil Classification, parent material and texture are listed in Table 5. The data in them were derived from the detailed soil descriptions and soil particle size analysis.

Samples were collected from the wall of each soil pit by depth horizons (0-20, 20-50 and 50-100 cm) and used for various analyses as described below. At most sites a single soil pit was dug but at some sites two pits were dug to capture potential variation in soil properties across the site. The soil nitrogen, carbon, coarse fractions and the percent sand, silt and clay are listed in Table 6. Table 7 contain the soil bulk density data and soil moisture data that were calculated from moisture release curves.

1. Prior to measuring the N and C concentration in the soil, a soil sample from each horizon was sieved to remove all roots, dried and analyzed for C and N by flash combustion using a Carlo-Erba EA 1108 analyzer.
2. To determine the coarse fraction (> 2mm) in the soil, samples were collected, weighed and then sieved. The fraction of material that did not pass through the 2 mm sieve was weighed and expressed as a percent of the total weight of the soil sample.
3. The portion of the sample that passed through the 2 mm sieve was used to determine the percent sand, silt and clay in that sample by weight.
4. Soil bulk density was measured (3 replicates per site) in each horizon using the metal core method described by Blake and Hartge (1986) and Elliott et al. (1999).
5. To determine available water capacity (AWC), three undisturbed soil core segments were collected at each site to represent each horizon and carefully wrapped in plastic wrap, labeled, placed in a protective soil tin, and placed in a cooler. A 5 point moisture release curve was run on each sample following the methods described by Klute (1986). For each soil horizon and site, field capacity (FC, -0.033 MPa) and permanent wilting point (PWP, -1.5 MPa) were estimated from soil moisture release curves and AWC was calculated. For example, AWC for 0 – 20 cm depth increment ($AWC_{0-20\ cm}$) is equal to $FC_{0\text{-}20\ cm} - PWP_{0\text{-}20\ cm}$.

References

Blake, G.R., Hartge, K.H., 1986. Bulk density. In: Klute, A. (Ed.) Methods of Soil Analysis. Part 1. Physical and Mineralogical Methods. Agronomy Monograph no. 9. American Society of Agronomy, Soil Science Society of America, Madison, WI, pp. 363-376.

Bréda, N.J.J. 2003. Ground-based measurements of leaf area index: a review of methods, instruments and current controversies. Journal Experimental Botany 54: 2403-2417.

Elliott, E.T., Heil, J.W., Kelly, E.F., Monger, H.C., 1999. Soil structural and other physical properties. In: Robertson, G.P., Coleman, D.C., Bledsoe, C.S., Sollins, P. (Eds.) Standard Soil Methods for Long-Term Ecological Research. Long-Term Ecological Research Network Series. Oxford University Press, NY, pp. 74-85.

Klute, A., 1986. Water retention: Laboratory methods. In: Klute, A. (Ed.) Methods of Soil Analysis. Part 1. Physical and Mineralogical Methods. Agronomy Monograph no. 9. American Society of Agronomy, Soil Science Society of America, Madison, WI, pp. 635-662.

Table 1. The geographic locations and elevations of the forest and open meteorological towers at the Oregon field sites. Table includes site code used in data files, forest type, and dates when meteorological data collection began and ended (if applicable).

Site Name	Data File Site Code	Meterological Station Location	Forest Type	Latitude (WGS83 Datum) NORTH (DMS)	Longitude (WGS83 Datum) WEST (DMS)	Elevation (m)	Start Date	End Date
Cascade Head Open	CHO	Open Area		45 02 29.15074	123 54 40.04828	157	9/9/1999	
Cascade Head_Stand 14	CH14	Forest	Douglas Fir	45 02 29.87084	123 54 34.28827	190	9/9/1999	
Cascade Head_Stand 14_Upper Canopy	UC_CH14	Top of Tree	Douglas Fir	45 02 29.87084	123 54 34.28827	290	9/12/2011	
Cascade Head_Stand 22	CH22	Forest	Alder-Conifer	45 02 26.27072	123 54 43.64825	170	7/26/2006	
Cascade Head_Stand 3	CH3	Forest	Sitka-Hemlock	45 02 44.27095	123 54 14.48843	204	8/22/2001	
Cascade Head_Stand 3_Upper Canopy	UC_CH3	Top of Tree	Sitka-Hemlock	45 02 44.27095	123 54 14.48843	304	9/19/2011	11/25/2013
Widow Creek	WCF	Forest	Douglas Fir	45 02 13.06	123 51 08.88	132	10/16/2015	
Collier Glacier Edge	CGE	Open Area		45 10 15.94	121 47 24.21	2296	4/19/2010	8/8/2014
Falls Creek Forest	FCF	Forest	Douglas Fir	44 23 46.13171	122 22 24.20128	528	10/25/1995	
Falls Creek Forest_Upper Canopy	UC_FCF	Top of Tree	Douglas Fir	44 23 46.13171	122 22 24.20128	628	9/10/2009	
Falls Creek Open	FCO	Open Area		44 23 47.21170	122 22 38.96173	534	11/22/1996	
Juniper	JUN	Forest	Juniper	44 13 24.38116	121 23 56.93909	975	9/23/1999	1/30/2015
Metolius	MET	Forest	Ponderosa Pine	44 29 24.13991	121 37 57.95724	918	6/10/1998	
Middle Santiam Forest	MSF	Forest	Douglas Fir	44 30 52.00681	122 15 27.31887	488	10/13/1999	10/30/2007
Moose Mountain Forest	MMF	Forest	Douglas Fir	44 24 52.73078	122 23 39.44497	658	5/7/1998	
Moose Mountain Forest_Upper Canopy	UC_MMF	Top of Tree	Douglas Fir	44 24 52.73078	122 23 39.44497	758	10/16/2009	
Moose Mountain Open	MMO	Open Area		44 24 40.85095	122 23 52.04506	668	4/21/1999	
Soapgrass Forest	SGF	Forest	Douglas Fir	44 20 53.69376	122 17 30.42839	1190	7/2/1998	
Soapgrass Forest_Upper Canopy	UC_SGF	Top of Tree	Douglas Fir	44 20 53.69376	122 17 30.42839	1290	10/21/2008	
Soapgrass Open	SGO	Open Area		44 20 42.89390	122 17 38.34836	1206	7/16/1998	
Tingey National Forest	TNF	Forest	Douglas Fir	44 33 56.67647	123 17 35.55921	76	12/18/1997	
Toad Creek Forest	TRF	Forest	Douglas Fir	44 25 34.83846	122 01 58.71795	1198	10/12/1995	
Toad Creek Forest_Upper Canopy	UC_TRF	Top of Tree	Douglas Fir	44 25 34.83846	122 01 58.71795	1298	8/25/2011	
Toad Creek Forest_Upper Canopy, Noble Fir	UC_TRF_NF	Top of Tree	Noble Fir	44 25 34.83846	122 01 58.71799	1298	6/22/2015	6/21/2016
Toad Creek Open	TRO	Open Area		44 25 33.39879	122 02 19.95879	1202	1/1/1997	
Western Ecology Division	WED	Open Area		44 33 55.95645	123 17 39.51930	76	1/1/1993	

Table 2. A listing of the weather and soil sensors typically found at the forest and open meteorological towers at the Oregon field sites.

Aboveground sensors	
Measured Parameter	**Units**
Air temperature	°C
Relative humidity	%
Photosynthetically Active Radiation (PAR)	µmol m-2 sec-1
Precipitation	mm hr -1
Wind speed	m sec-1
Snow depth (only at with sites frequent snow)	cm

Belowground Sensors	
Measured Parameter	**Units**
Soil temperature @ surface 5, 15, 30 cm	°C
Volumetric soil moisture 0-20, 20-40, 40-60 cm	v/v

Table 3. Dates when sensor positions were changed from their original installation locations to standard locations and the settings of the original locations.

			Measurement Parameter and Sensor Model Used					
Site ID	**Date Sensor Positions Changed**	**Sensor Position**	**Temperature & RH (Vaisala HMP35)**	**Temperature & RH (Vaisala HMP45)**	**Photosynthetically Active Radiation (PAR) - Up Facing (LI-COR LI-190SL)**	**Photosynthetically Active Radiation (PAR) - Down Facing (LI-COR LI-190SL)**	**Precipitation (Texas Electronics TE525I)**	**Wind Speed (Met One 014A)**
FCO	2/18/2000	Original Height Above Ground (cm)	232	300	353		286	366
		Original Distance From Tower Center (cm)	50	23	366		18	239
		Original Installation Bearing (°True)	185	33.5	170		265	80
FCF	2/11/2000	Original Height Above Ground (cm)	226		334	269	306.6	335
		Original Distance From Tower Center (cm)	16.5		61.5	58	68	54
		Original Installation Bearing (°True)	155		136	62	241	320
MMO	7/6/2000	Original Height Above Ground (cm)		243	282.5		312.5	317
		Original Distance From Tower Center (cm)		16	95		68.5	51
		Original Installation Bearing (°True)		17	198		282	110
MMF	4/25/2000	Original Height Above Ground (cm)		270	297.2		327	325.5
		Original Distance From Tower Center (cm)		16.2	94.7		61.5	49.8
		Original Installation Bearing (°True)		23	204		306	121

SGO	7/13/1999	Original Height Above Ground (cm)		246	538		303	300
		Original Distance From Tower Center (cm)		16	30		66	56.5
		Original Installation Bearing (°True)		28	235		28	208
SGF	6/15/2000	Original Height Above Ground (cm)		263	294		305.5	310.5
		Original Distance From Tower Center (cm)		16	94		69	58
		Original Installation Bearing (°True)		19	199		105	287
TRO	7/19/2000	Original Height Above Ground (cm)	237	291	290		295	287
		Original Distance From Tower Center (cm)	64	73.5	75.5		82	75.5
		Original Installation Bearing (°True)	98	0	174		314	58
TRF	6/21/2000	Original Height Above Ground (cm)	248		322	249	313	343
		Original Distance From Tower Center (cm)	16		58	56.5	68	57
		Original Installation Bearing (°True)	19		199	269	90	19

Table 4. The stand characteristics of the field sites in Oregon.

Field Site	Stand Age (years)	Stand Establishment Event	Dominate tree species[a]	Year Stand Data	Stand Density, Number trees $\geq$ 20 cm (number ha^{-1})	Basal Area, (trees $\geq$ 20 cm) (m^2 ha^{-1})	Leaf Area Index[b]	Foliar N (%)	Year Root Data	Fine Root Biomass[b] (g m^{-2})
Cascade Head Stand 3	150-160	Fire	PISI, TSHE	1998	207	108.0	6.5 $\pm$ 0.6		1999	481 $\pm$ 77
Cascade Head Stand 14	150-160	Fire	PSME, TSHE	2003	241	82.2	5.9 $\pm$ 0.2	1.26 $\pm$ 0.03	1999	392 $\pm$ 53
Moose Mountain	90-100	Fire	PSME	2001	212	60.8	8.9 $\pm$ 0.4		2002	660 $\pm$ 73
Falls Creek	110-140	Fire	PSME	2004	185	59.5	8.9 $\pm$ 0.8	1.18 $\pm$ 0.03	1998	583 $\pm$ 52
Soapgrass	>500	Fire	PSME, TSHE	1998	256	147.9	6.8 $\pm$ 0.8	1.20 $\pm$ 0.03	1998	741 $\pm$ 80
Middle Santiam										
Toad Creek	200-250	Fire	PSME, TSHE	2000	252	85.3	6.6 $\pm$ 0.6	1.10 $\pm$ 0.03	1998	1652 $\pm$ 85
Metolius			PIPO						1999	614 $\pm$ 79
Juniper			JUOC	2001/02	82	17.9			2001	778 $\pm$ 53

a. The abbreviations for the tree species are as follows: ABLA – Abies lasiocarpa, JUCO – Juniperus occidentalis, PIPO – Pinus ponderosa, PISI –Picea sitchensis, PSME – Pseudotsuga menziesii, TSHE – Tsuga heterophylla

b. Leaf area index and fine root biomass are expressed as the mean and associated standard error for each site.

Table 5. The field site –Soil Classifications, Parent Material and Texture at the field sites in Oregon.

Field Sites	Soil Classification	Soil Parent Material	Soil Texture		
			0-20 cm	20-50 cm	50-100 cm
Cascade Head Stand 3 - North Soil Pit	Medial, mixed, Typic Hapludands	aoelian silt over more weathered tuffaceous siltstone	silt loam/loam	silt loam	loam
Cascade Head Stand 3 - South Soil Pit	Medial, mixed, Typic Fulvudands	aoelian silt over more weathered tuffaceous siltstone	silt loam/loam	silt loam	loam
Cascade Head Stand 14 - Site 1	Medial, mixed, Typic Fulvudands	aoelian silt over weathered tuffaceous siltstone	loam	loam/clay loam	clay loam
Cascade Head Stand 14 - Site 2	Medial, mixed, Typic Hapludands	aoelian silt perhaps over weathered tuffaceous siltstone	loam	loam/clay loam	clay loam
Moose Mountain	Medial, amorphic, Typic Hapludands	Volcanic ash over weathered volcanic ash over tuffs and breccia bedrock	loam	Clay Loam	Silty Clay Loam
Falls Creek	Fine-loamy, mesic, Andic Dystrudepts	volcanic ash over weathered volcanic ash over weathered tuff and breccia bedrock	gravelly loam	silty clay/clay	clay
Soapgrass - South Pit	Medial-skeletal, amorphic, Typic Fulvudands	volcanic ash over glacial till derived from volcanic materials	gravelly loam	gravelly loam	loam
Soapgrass - North Pit	Medial-skeletal, amorphic, Typic Fulvcryands	volcanic ash over glacial till derived from volcanic materials	na	na	na
Middle Santiam	Medial, Typic Hapludands	Alluvium and volcanic ash over weathered volcanic ash over tuffs and breccia bedrock	sandy loam	sandy loam	sandy loam
Toad Creek	Medial-skeletal, Typic Fulvicryands	volcanic ash over volcanic ash mixed with glacial till	loamy sand	gravelly sandy loam/loam	gravelly loamy sand
Metolius	Ashy over loamy, mixed, frigid Alfic Vitrixerands	Volcanic ash and pumice over high Cascades volcanics	loamy sand	gravelly loamy sand	sandy loam
Juniper	Ashy, mesic Vitritorrandic Haploxerolls	Volcanic ash and High Cascades Volcanics	loamy sand	loamy sand	loamy sand

Table 6. Soil Nitrogen, Carbon, Coarse Fraction and Percent Sand, Silt and Clay at the Oregon Field Sites.

Field Sites	Horizon Depth Increment	Nitrogen %	Carbon %	Coarse Fraction >2mm %	Sand 2mm-50um %	Silt 50um-2um %	Clay <2um %
Cascade Head Stand 3	O Horizon	1.17	41.37				
	0 – 20 cm	0.78	17.61	0.5	31.0	50.7	18.3
	20 – 50 cm	0.37	6.83	0.8	24.3	54.4	21.3
	50 – 100 cm	0.16	2.59	0.8	37.3	38.7	24.0
Cascade Head Stand 14	Oi Horizon	1.34	45.25				
	0 – 20 cm	0.46	9.51	7.6	34.8	41.0	24.2
	20 – 50 cm	0.27	5.14	2.1	29.1	44.0	26.9
	50 – 100 cm	0.12	1.81	3.2	32.7	38.1	29.2
Moose Mountain	Oi/Oe Horizon	0.84	26.57				
	0 – 20 cm	0.35	12.35	35.8	35.7	40.9	23.4
	20 – 50 cm	0.12	2.42	20.6	26.9	44.7	28.4
	50 – 100 cm	0.06	1.05	9.3	19.5	44.8	35.7
Falls Creek	O Horizon	1.17	34.60				
	0 – 20 cm	0.29	9.14	30.4	31.2	43.5	25.4
	20 – 50 cm	0.11	3.19	2.4	13.6	39.6	46.8
	50 – 100 cm	0.06	0.52	0.5	17.2	32.1	50.8
Soapgrass	Oi/Oa Horizon	1.00	38.68				
	0 – 20 cm	0.43	14.30	15.0	50.3	40.2	9.5
	20 – 50 cm	0.24	5.77	17.9	50.1	40.8	9.1
	50 – 100 cm	0.13	2.19	13.7	40.5	41.8	17.7
Middle Santiam	Oi/Oe Horizon	1.23	39.58				
	0 – 20 cm	0.20	3.27	0.5	60.1	31.0	8.9
	20 – 50 cm	0.09	1.34	0.4	62.7	28.6	8.7
	50 – 100 cm	0.05	0.52	0.5	74.0	20.1	5.9
Toad Creek	O Horizon	1.09	38.44				
	0 – 20 cm	0.19	7.46	6.0	84.0	12.4	3.6
	20 – 50 cm	0.12	2.37	19.4	51.3	42.0	6.6
	50 – 100 cmC	0.10	1.66	30.6	78.7	18.0	3.3
Metolius	Oi Horizon	0.92	46.51				
	0 – 20 cm	0.09	4.77	11.4	73.9	23.0	3.1
	20 – 50 cm	0.03	0.44	20.4	75.5	21.5	2.9
	50 – 100 cm	0.05	0.90	6.7	59.0	34.4	6.5
Juniper	0 – 20 cm	0.10	1.62	6.9	79.5	17.2	3.3
	20 – 500 cm	0.04	0.33	4.3	79.6	17.0	3.4
	50 – 100 cm	0.02	0.11	5.6	82.8	14.6	2.6

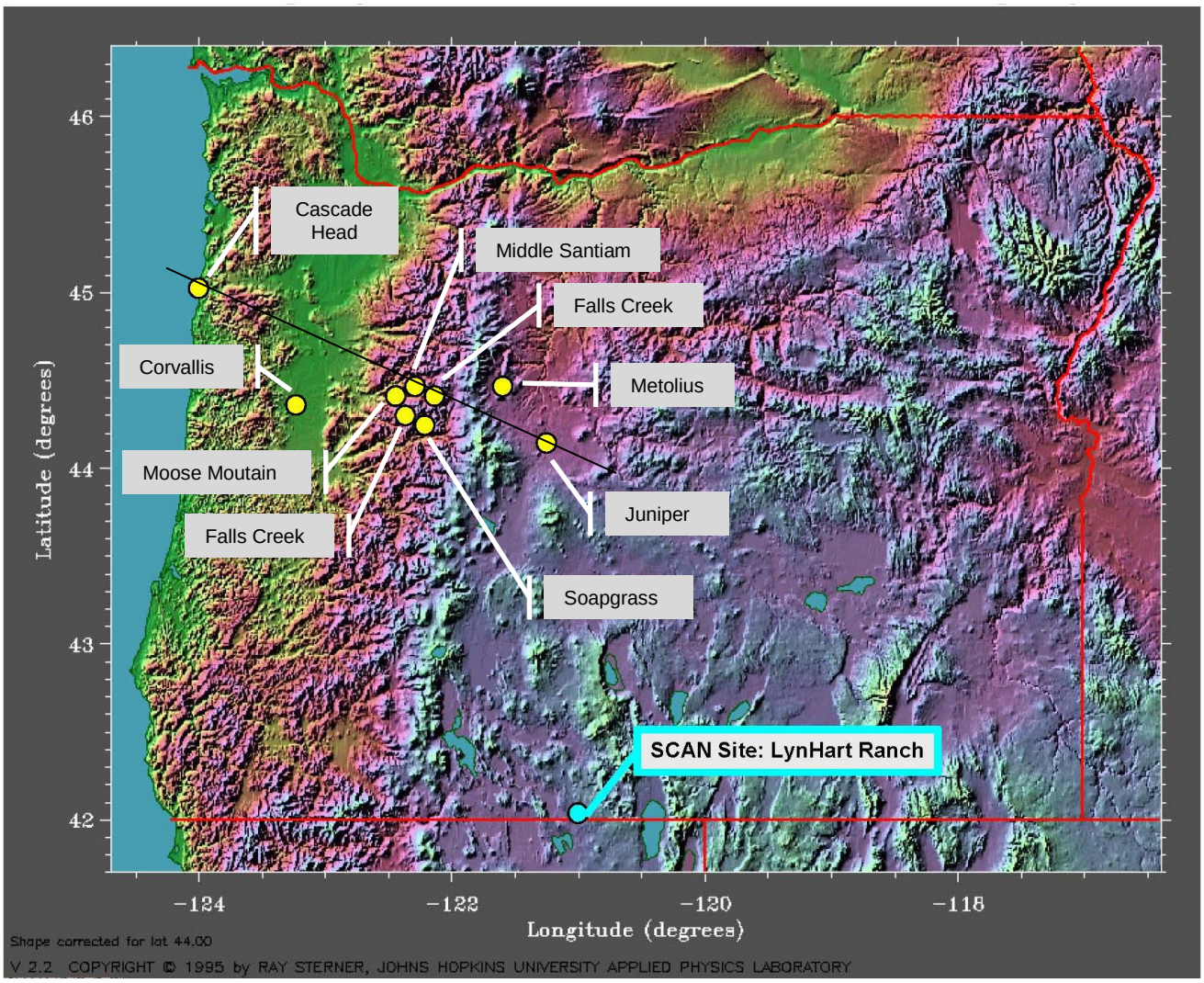
Table 7. Soil bulk density and soil water content at the Oregon field sites.

Field Sites	Soil Depth cm	Bulk Density g cm^{-3}	Volumetric Water Content g H_2O cm^{-3} soil			Liters water m^{-2} per horizon			Available water mm m^2 per horizon	[a] Available Soil Water (0 - 60 cm) mm mean & SD
			Field Capacity	Wilting Point	Maximum Available Water	Field Capacity	Wilting Point	Maximum Available Water		
Cascade Head Stand 3	0-20	0.64	79.39	12.10	67.29	158.8	24.2	134.6	134.6	369.2 ± 91.7
	20-50	0.76	77.10	13.11	64.00	154.2	26.2	128.0	128.0	
	50-100	0.73	52.94	10.42	42.52	130.0	23.5	106.5	106.5	
	Sum					443.0	73.9	369.1	369.1	
Cascade Head Stand 14	0-20	0.75	62.32	19.93	42.38	124.6	39.9	84.8	84.8	239.4 ± 26.2
	20-50	0.85	61.91	19.44	42.47	123.8	38.9	84.9	84.9	
	50-100	0.94	49.04	21.84	27.20	111.0	41.3	69.7	69.7	
	Sum					359.4	120.0	239.4	239.4	
Moose Mountain	0-20	0.75	27.63	16.47	11.15	55.3	32.9	22.3	22.3	80.2 ± 6.2
	20-50	0.84	32.73	18.51	14.22	65.5	37.0	28.4	28.4	
	50-100	0.86	34.71	19.47	15.24	67.4	38.0	29.5	29.5	
	Sum					188.2	107.9	80.2	80.2	
Falls Creek	0-20	0.82	31.30	9.22	22.08	62.6	18.4	44.2	44.2	144.6 ± 11.7
	20-50	0.99	43.60	21.38	22.22	87.2	42.8	44.4	44.4	
	50-100	1.40	57.23	23.49	33.73	100.8	44.9	56.0	56.0	
	Sum					250.6	106.1	144.6	144.6	
Soapgrass	0-20	0.56	31.72	5.87	25.85	63.4	11.7	51.7	51.7	160.6 ± 6.0
	20-50	0.63	31.53	5.03	26.51	63.1	10.1	53.0	53.0	
	50-100	0.79	33.95	5.47	28.49	65.5	10.5	55.0	55.0	
	Sum					192.0	32.3	159.7	159.7	

Middle Santiam	0-20	0.84	30.90	14.13	16.77	61.8	28.3	33.5	33.5	70.2 $\pm$ 13.1
	20-50	1.10	22.93	12.35	10.58	45.9	24.7	21.2	21.2	
	50-100	1.53	14.45	10.54	3.91	37.4	22.9	14.5	14.5	
	Sum					145.0	75.9	69.2	69.2	
Tingey Natural Forest	0-20	0.93	34.74	11.64	23.1	69.5	23.3	46.2	46.2	123.3 ± 11.5
	20-50	0.89	29.17	11.24	17.93	58.3	22.5	35.9	35.9	
	50-100	0.86	36.85	13.52	23.33	66.0	24.8	41.3	41.3	
	Sum					193.9	70.5	123.3	123.3	
Toad Creek	0-20	0.72	23.32	7.88	15.44	46.6	15.8	30.9	30.9	83.4 $\pm$ 20.9
	20-50	0.75	17.93	7.32	10.61	35.9	14.6	21.2	21.2	
	50-100	0.78	29.91	9.20	20.71	47.8	16.5	31.3	31.3	
	Sum					130.3	46.9	83.4	83.4	
Metolius	0-20	1.02	18.76	7.63	11.13	37.5	15.3	22.3	22.3	69.2 $\pm$ 3.7
	20-50	1.15	19.01	7.12	11.89	38.0	14.2	23.8	23.8	
	50-100	1.07	22.78	11.47	11.30	41.8	18.6	23.2	23.2	
	Sum					117.3	48.1	69.2	69.2	
Juniper	0-20	1.10	19.28	6.95	12.33	38.6	13.9	24.7	24.7	68.0 $\pm$ 5.1
	20-50	1.16	18.11	6.58	11.54	36.2	13.2	23.1	23.1	
	50-100	1.29	16.70	8.00	8.70	34.8	14.6	20.2	20.2	
	Sum					109.6	41.6	68.0	68.0	

a Available Soil Water (0 - 60 cm) is given as the mean and standard deviation to a depth of 60 cm in the soil and is based on 3 observations.

Figure 1. A map of the field sites located in Oregon and the elevation profile along this transect.



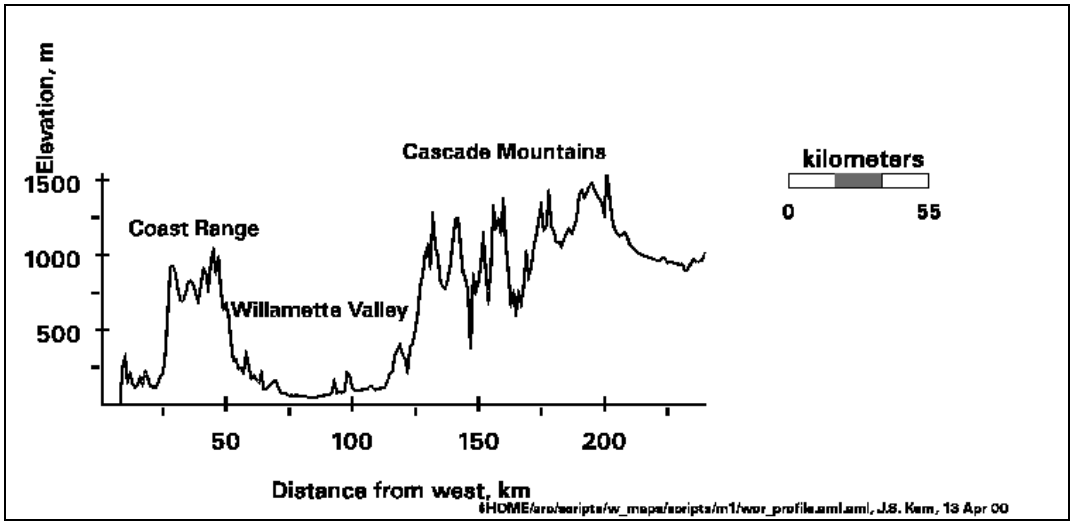
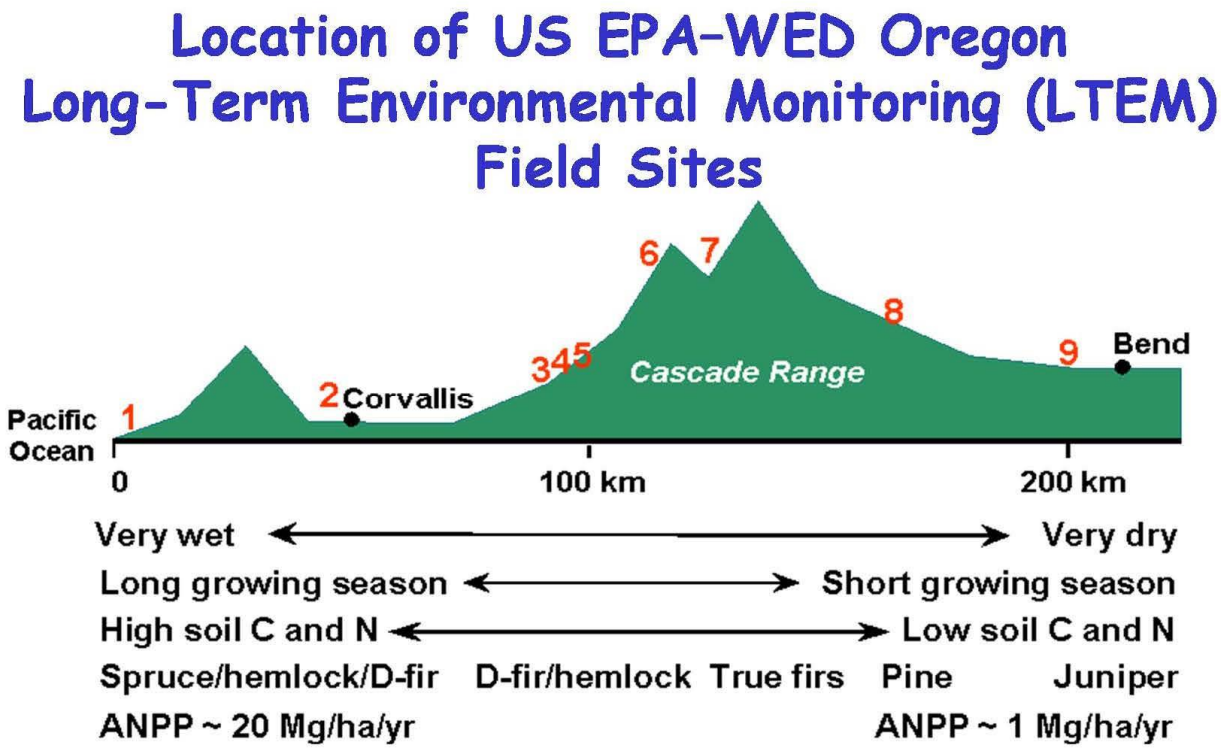


Figure 2. Location of field sites along stylized elevation profile, physical and biological characteristics across this transect, and names and major features of the various sites.



1) Cascade Head (3 Forest & 1 Open)
Elevation ~ 140 m
Forest Types: Douglas-fir, Sitka Spruce, Alder
Stand Age: ~ 150 yrs

2) Corvallis – TNF & WED
Elevation ~ 70 m
Forest Type: Douglas-fir & Open
Stand Age: ~ 30 yrs

3) Falls Creek Forest & Open
Elevation ~ 540 m
Forest Type: Douglas-fir
Stand Age: ~ 140 yrs

4) Moose Mountain Forest & Open
Elevation ~ 600 m
Forest Type: Douglas-fir
Stand Age: ~ 140 yrs

5) Middle Santiam Forest
Elevation ~600 m
Forest Type: Douglas-fir
Stand Age: > 250 yrs

6) Soapgrass Forest & Open
Elevation ~ 1220 m
Forest Type: Douglas-fir
Stand Age: ~ 455 yrs

7) Toad Creek Forest & Open
Elevation ~ 1220 m
Forest Type: Douglas-fir
Stand Age: ~ 220 yrs

8) Metolius
Elevation ~ 900 m
Forest Type: Ponderosa Pine
Stand Age: ~ 200 yrs

9) Juniper
Elevation ~ 900 m
Forest Type: Juniper
Stand Age: > 200 yrs

Figure 3. Typical climate station and climate monitoring sensors for forest and open area.

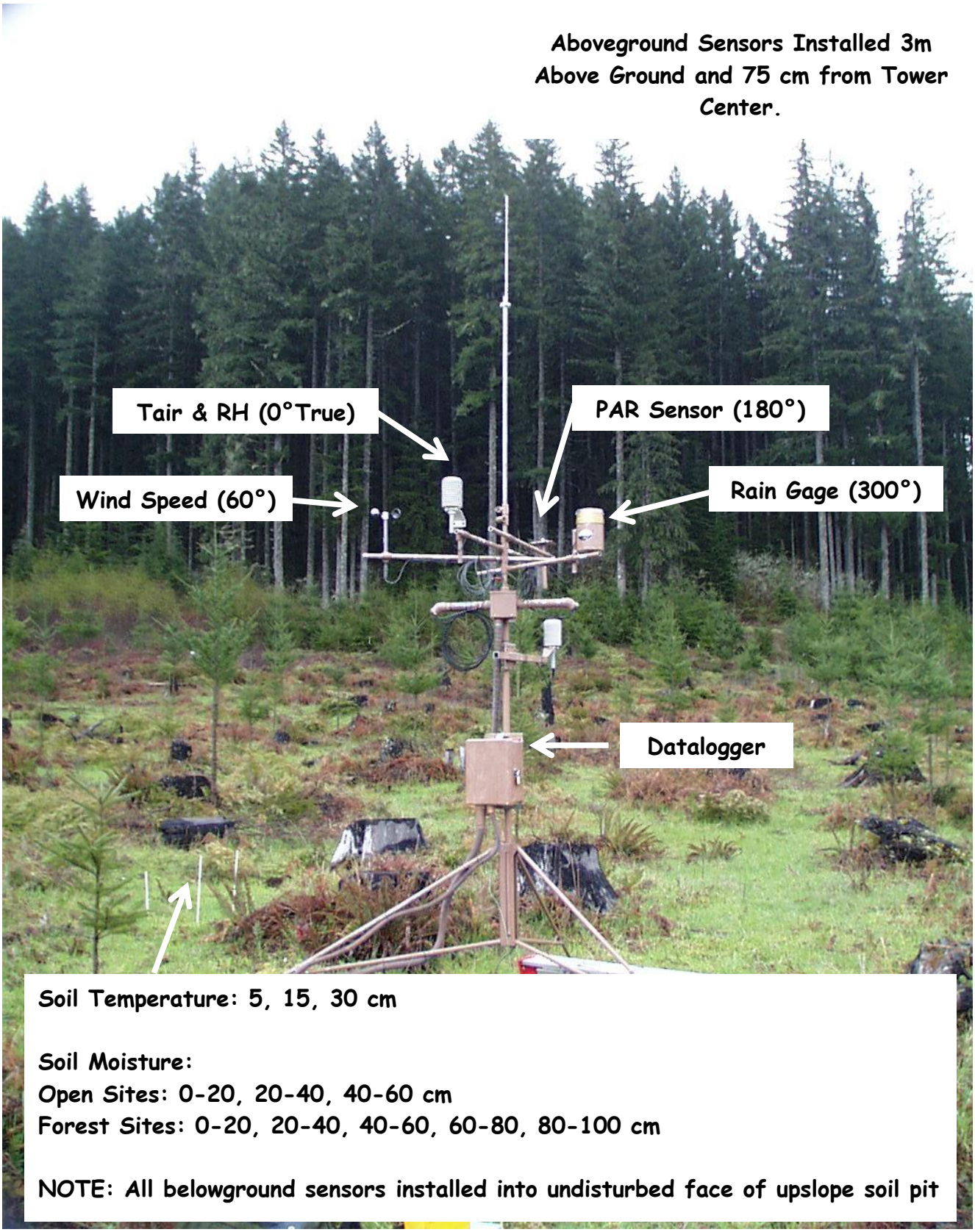


Figure 4. Typical climate station and climate monitoring sensors for upper canopy locations.